7.12

STANDARD OPERATING PROCEDURES
FOR MEASURING STREAM DISCHARGE
AT WADABLE STREAMS, ROUND CULVERTS, AND WEIRS

Summary

Flow is measured to calculate instantaneous discharge and to develop a hydraulic volume rating curve. For hydraulic rating curve development stage measurements are collected over the entire range of stage and flow for accuracy.

The rating curve is calculated either mathematically using a slope equation that best fits the field data [discharge (cfs) = M (stage (ft)) + B], or by manually plotting the relationship. When calculating the relationship, M is the slope and B is the y-axis intercept. Both will be derived from a regression using flow as the dependent variable and stage as the independent variable.

Ideally the regression R squared value should be greater than 0.85 and significant at the $p \leq 0.05$ level. When graphed the calculated curve should be a close fit to the actual data at the high flow, median flow, and low flow. When a satisfactory equation has been calculated for a particular site it can then be used for many years to estimate average daily discharge with a minimum of annual maintenance measurements.

Careful selection of sampling sites can greatly reduce the amount of work required to calculate accurate discharge measurements. Ideal sites are: weirs, bridges, box culverts and round culverts. The advantage of these sites is that a minimum number of measurements are needed to determine a significant flow and stage relationship, and discharge measurements are possible from above during high flow periods. When none of the above situations exist and the stream is small enough, a temporary weir may be constructed to aid in collecting flow measurements.

Flow readings should be collected from the same location throughout the study period. If for any reason the location has to be moved, data will be collected at both sites over a wide enough range in flow to ensure accuracy is not lost during transition. The new location will be noted in the field log along with an explanation as to why it was moved.

Equipment and supplies

Flexible metal, Kevlar, or fiberglass measuring tap	Field Sheets
Velocity meter	Pencil
Wading rod	Stakes

Procedures Collecting Discharge in Wadable Stream

Measuring stream discharge is accomplished by collecting cross sectional measurements of flow velocities, stream width and stream depth. General guidelines for distance between measurements are 1 foot for streams 20 feet wide or less, 2 feet for streams 21 to 40 feet across, and 3 feet for streams greater then 40 feet.

No individual section measured should exceed 10 percent of the total stream discharge. If a segment exceeds 10 percent, additional measurements will be collected until less then 10 percent of total flow is represented in all sections.

Flow velocity in segments 3 feet or less will have a single measurement collected at 60 percent of the total depth. Segments greater then 3 feet will have 2 measurements collected: one at 20 percent of the total depth and one at 80 percent of the total depth.

Procedure

1. Fill out upper portion of flow form (Figure 7.12.1) including site identification number, date, time, sampler(s), description of site, gauge height, method, and type of meter.

2. Anchor the tape at the near shore and stretch it across the stream at a perpendicular to stream flow.

3. Check meter calibration according to owners manual.

4. Segment 1 begins at the left edge of water (left bank facing down stream).

5. The first reading is at the waters edge and recorded as segment 1. Distance, depth, and velocity are all zero (Figure 7.12.1).

6. Enter the waterbody downstream of the tape. Face into the current with the rod upstream of your body so as not to influence flow.

7. The second reading should be taken as soon as the stream reaches a depth of 0.2 or 0.4 feet, or one half of the distance to the following segment.

8. Record the distance from point 1 and the water depth.

9. Adjust the velocity meter to 60 percent of the depth.

10. Slowly pivot the velocity meter back and forth until the greatest velocity at that segment is found.

11. Record the velocity.

12. Repeat steps 6 through 9 until the opposite bank is reached. The final reading is the right edge of water. As was the case with segment 1, depth and velocity are zero.

     a.   Discharge will be calculated individually for each segment. The flow is the area multiplied by velocity. The total discharge is the sum of segments.

Collecting Discharge in Round Culverts

1.   Measure the radius (R) of the culvert in feet.

2.   Measure water depth (D) in center of culvert in feet.

3.   Measure velocity (V) in the center of the culvert at 60% of total water depth if 3 feet deep or less. Measure the velocity (V) at 20% and 80% of total water depth if greater then 3 feet deep.

4.   Calculate the area (A) of the discharge with the following formula:

$$Area\ (A) = \frac{\pi R^2}{2} + [R\text{-}D\sqrt{R^2\text{-}(R\text{-}D)^2} + R^2 arcos(\frac{R\text{-}D}{R})]$$

5.   Calculate discharge (cfs) by the following formula:

          Discharge (cfs) = V (0.8)*A
          Where: V (0.8) = average velocity of the discharge
                 A = area of the discharge

Collecting Discharge at a Weir

1.   To physically measure discharge over a weir the procedure is the same as in an open stream bed. The first reading is taken on the edge of the nearest wall of the weir, the second and subsequent readings are taken over the top of the weir ending on the farthest wall.

2.   To mathematically estimate discharge over a weir the following formula is used:

$$Q=MLH\acute{}\sqrt{2GH}$$

Where: Q = discharge in cubic feet/second (cfs)

$$M = (0.405+0.\frac{00984}{H})\acute{}(1+0.55(\frac{H}{P+H})^2)$$

L = length of weir in feet
H = head (feet)
G = the acceleration due to gravity = 32.16 feet/second
P = the height (feet) of the head over the downstream surface

When using the above equation many variables affect the accuracy of the output. To ensure accurate computations, a limited amount of physical discharge measurements should be collected. If a variation greater than five percent is discovered, the equation should be.

North Dakota Department of Health
Division of Water Quality
Discharge Measurement Record
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Project Code:		Project Name:		
Site Identification:		Site Description:		
Date:	Sampler(s):			
Method:	Meter No.	Meter Type:	Discharge Units:	
No. Sections:	Stage Start:	Stage End:	Stage change:	
Samples Collected:	Time Start:	Time End:	Time change:	
Water Quality, Sediment, Bacterial, Fish, Macroinvertebrate, other:				
Comments:				

Distance from Point (ft)	Width (ft)	Depth (ft)	Velocity(ft/sec)	Area (ft^2)	Discharge (cfs)
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					

Figure 7.12.1. Discharge Measurement Form